potentially reduce the cost enough that disposable surgical probes would be economically feasible. Further, the optical fibers are more robust than LED's and are therefore more suitable for autoclaving in medical environments. Lastly, the optical light source can be a laser (diode or gas) which has the potential for generating more light than the simple LED used in the prior art.

While this invention has been described above with reference to several preferred embodiments, a person of ordinary skill in the art should be able to readily visualize alternative embodiments which do not materially depart from the scope of this invention. Therefore, the scope and content of this invention are not limited by the foregoing description. Rather, the scope and content are to be defined by the following claims.

What is claimed is:

1. An apparatus for determining the location of at least one point in three dimensional space relative to a three dimensional coordinate system defining said space comprising:

at least one emitter of electromagnetic radiation, comprising a radiation dispersing element which emits said radiation in a substantially conical pattern which at least approaches a [[solid angle of about 180°] hemisphere, wherein said radiation emission pattern has a centroid such that it at least closely approximates a point source of said radiation thereby causing said centroid of said electromagnetic radiation to be in a substantially invariant relationship to said emitter of said radiation regardless of the angle from which the centroid of the emitted radiation is viewed;

an electromagnetic radiation generator operatively associated with each of said emitters;

means for transmitting electromagnetic radiation generated by said generator to said emitter;

a plurality of electromagnetic radiation sensors, each of which is adapted to detect at least one electromagnetic ray emitted from at least one of said emitters;

a power supply for said electromagnetic radiation generator;

where there are a plurality of emitters, means to differentiate electromagnetic radiation emitted by at least two of said emitters; and

means for determining the location of said emitter relative to the three dimensional coordinate system;

wherein, as a consequence of said emitters emitting electromagnetic radiation at a solid angle of at least approaching [180°] a hemisphere, determining the location of said emitters with greater accuracy than would have been the accuracy determined had the electromagnetic radiation been generated without said dispersing element.

2. The apparatus as claimed in claim 1, wherein at least one of said dispersing element comprises a diffuser.

3. The apparatus as claimed in claim 2, wherein the diffuser is substantially a section of a sphere.

4. The apparatus as claimed in claim 2, wherein the diffuser is substantially flat.

5. The apparatus as claimed in claim 1, wherein at least one of said emitters comprises a light pipe image guide which is so shaped as to be capable of emitting electromagnetic radiation from an end thereof at a solid angle at least approaching [180°] a hemisphere.

6. The apparatus as claimed in claim 1, wherein at least one of said emitters comprises a concave lens with a negative focal length capable of emitting electromagnetic radiation at a solid angle at least approaching [180°] a hemisphere.

7. The apparatus as claimed in claim 1 wherein at least one of said emitters comprises a curved, convex mirror capable of emitting reflected electromagnetic radiation at a solid angle at least approaching [180°] a hemisphere.

8. The apparatus as claimed in claim 1 wherein said electromagnetic radiation comprises visible light.

9. The apparatus as claimed in claim 1 wherein said electromagnetic radiation comprises infra red light.

10. The apparatus as claimed in claim 1 wherein said electromagnetic radiation comprises ultra violet light.

11. The apparatus of claim 1 comprising a plurality of emitters.

12. The apparatus as claimed in claim 1 comprising a separate electromagnetic radiation generator associated with each emitter.

13. The apparatus as claimed in claim 11 wherein each of said emitters radiates at a different wavelength.

14. The apparatus as claimed in claim 1 wherein said at least one emitter is disposed on an object in said three dimensional space, and wherein said electromagnetic radiation generator is disposed proximate to said emitter.

15. The apparatus as claimed in claim 1 wherein said at least one emitter is disposed on an object in said three dimensional space, said electromagnetic radiation generator is disposed a distance from said emitter, and at least one electromagnetic radiation guide is disposed therebetween in operative relationship to both said generator and said emitter.

16. The apparatus as claimed in claim 14 wherein said electromagnetic radiation generator is disposed in or on said object sufficiently proximate to said emitter as to exclude a radiation guide therebetween.

17. The apparatus as claimed in claim 15 wherein said electromagnetic radiation generator is powered by electricity, and wherein said emitter and said object are substantially electrically neutral.

18. The apparatus as claimed in claim 15 wherein said electromagnetic radiation generator is powered by electricity, and wherein said emitter and said object are substantially magnetically neutral.

19. The apparatus as claimed in claim 15 wherein said at least one emitter is unconnected to a source of electricity.

20. An electrically neutral system for radiating electromagnetic radiation from an effective point source comprising:

an electromagnetic radiation generator;

an emitter of electromagnetic radiation comprising a radiation dispersing element which emits said electromagnetic radiation in a substantially conical pattern through a solid angle which at least approaches [180°] a hemisphere,

wherein said radiation emission has a centroid such that it at least closely approximates a point source of said radiation thereby causing said centroid of said electromagnetic radiation to be in a substantially invariant relationship to the emitter of said radiation regardless of the angle from which the centroid of emitted radiation is viewed, and

wherein said emitter is disposed a distance from said generator;

at least one optical fiber disposed in operative relationship to both said generator and said emitter such that it is adapted to transmit electromagnetic radiation from said generator to said emitter; and

an electric power source operatively associated with said electromagnetic radiation generator, wherein said generator is substantially electrically and magnetically isolated from said emitter.

21. The apparatus as claimed in claim 20 wherein at least one of said dispersing element comprises a diffuser.

22. The apparatus as claimed in claim 21 wherein the diffuser is substantially a section of a sphere.

23. The apparatus as claimed in claim 21 wherein the diffuser is substantially flat.

24. The apparatus as claimed in claim 20 wherein at least one of said emitters comprises a light pipe image guide which is so shaped as to be capable of emitting electromagnetic radiation from an end thereof at a solid angle at least approaching [180°] a hemisphere.

25. The apparatus as claimed in claim 20 wherein at least one of said emitters comprises a concave lens with a negative focal length capable of emitting electromagnetic radiation at a solid angle at least approaching [180°] a hemisphere.

26. The apparatus as claimed in claim 20 wherein at least one of said emitters comprises a curved, convex mirror capable of emitting reflected electromagnetic radiation at a solid angle at least approaching[180°] a hemisphere.

27. The apparatus as claimed in claim 20 wherein said electromagnetic radiation comprises visible light.

28. The apparatus as claimed in claim 20 wherein said electromagnetic radiation comprises infra red light.

29. The apparatus as claimed in claim 20 wherein said electromagnetic radiation comprises ultra violet light.

30. The apparatus as claimed in claim 20 comprising a plurality of emitters.

31. The apparatus as claimed in claim 20 comprising a separate electromagnetic radiation generator associated with each emitter.

32. The apparatus as claimed in claim 30 wherein each of said emitters radiates at a different wavelength.

33. The apparatus as claimed in claim 20 wherein said at least one emitter is disposed on an object in said three dimensional space, and wherein said electromagnetic radiation generator is disposed proximate to said emitter.

34. The apparatus as claimed in claim 20 wherein said at least one emitter is disposed on an object in said three dimensional space, said electromagnetic radiation generator is disposed a distance from said emitter, and at least one electromagnetic radiation guide is disposed therebetween in operative relationship to both said generator and said emitter.

35. The apparatus as claimed in claim 33 wherein said electromagnetic radiation generator is disposed in or on said object sufficiently proximate to said emitter as to exclude a radiation guide therebetween.

36. The apparatus as claimed in claim 34 wherein said electromagnetic radiation generator is powered by electricity, and wherein said emitter and said object are substantially electrically neutral.

37. The apparatus as claimed in claim 34 wherein said electromagnetic radiation generator is powered by electricity, and wherein said emitter and said object are substantially magnetically neutral.

38. The apparatus as claimed in claim 34 wherein said at least one emitter is unconnected to a source of electricity.

39. A method of accurately determining the location of a point in three dimensional space which comprises:

electrically generating electromagnetic radiation;

non-electrically transmitting said electromagnetic radiation to an emitter, comprising a radiation dispersing element, so constructed as to emit electromagnetic radiation therefrom in a conical array through a solid angle at least approaching [180°] a hemisphere;

non-electrically emitting said electromagnetic radiation from said dispersing element in a substantially conical pattern over a solid angle that at least approaches about [180°] a hemisphere; and

thereby causing a centroid of said emitted electromagnetic radiation to at least closely approximate a point source of said radiation which is substantially invariant with respect to the emitter of said radiation regardless of the angle from which said emitted radiation is viewed.

40. A method as claimed in claim **39** further comprising generating said electromagnetic radiation a distance from said emitter; transporting said generated electromagnetic radiation non-electrically through at least one optical fiber from said electromagnetic generator to said emitter; and maintaining said emitter electrically and mechanically substantially neutral.

41. A method as claimed in claim **39** further including disposing at least one of said emitter on a three dimensional object; disposing an electromagnetic generator in operative association with a radiation guide in operative relationship with each of said emitters and remote from said object; and maintaining said object electrically and magnetically substantially neutral with respect to said electromagnetic generator.

42. A method of determining the position and orientation of at least one three dimensional object in a three dimensional space defined by a coordinate system which comprises:

disposing a plurality of electromagnetic emitters, comprising a dispersing element so constructed as to radiate electromagnetic radiation in a substantially conical pattern over a solid angle that at least approaches about [180°] a hemisphere in known spaced apart relationship to each other on a surface of said object;

providing at least one electromagnetic radiation generator spaced from said object;

providing a non-electric radiation guide operatively associated with each emitter and with said at least one generator;

generating electromagnetic radiation from each of said generators;

transmitting said radiation, non-electrically through said radiation guides to said emitters;

non-electrically radiating a substantially conical pattern of radiation from at least one of said dispersing elements;

receiving said emitted radiation by a plurality of electromagnetic radiation receivers;

determining the location of each emitter as a function of the angles between said received radiation and respective reference lines; and

converting said determined locations of said emitters to a position and orientation of said object in said three dimensional space.

43. A method as claimed in claim **42** wherein said dispersing element comprises a diffuser.

44. A method as claimed in claim **42** wherein said dispersing element comprises a section of a sphere.

45. A method as claimed in claim **42** wherein said dispersing element comprises a light pipe image guide so constructed as to emit said electromagnetic radiation over a solid conical angle at least approaching[180°] a hemisphere.

46. A method as claimed in claim **43** wherein said diffuser comprises a substantially flat plate.

47. A method as claimed in claim **42** wherein said dispersing element comprises a concave lens with a negative focal length.

48. A method as claimed in claim **42** wherein said dispersing element comprises a convex mirror.

* * * * *

49. The apparatus as claimed in claim 11 wherein at least two of said emitters rediate at a different wavelength.

50. An electrically neutral system for radiating electromagnetic radiation from an effective point source comprising:

at least one electromagnetic radiation generator;

at least one emitter of electromagnetic radiation comprising means for emitting radiation through a solid angle that at least approaches a hemisphere,

wherein said radiation emission has a centroid such that is at least closely approximates a point source of said radiation; and

wherein said emitter(s) is disposed a distance from said generator(s),

at least one optical fiber disposed in operative relationship to said generator(s) and said emitter(s) such that the fiber is adapted to transmit electromagnetic radiation from said generator(s) to said emitter(s); and

an electric power source operatively associated with said electromagnetic radiation generator, wherein said generator is substantially electrically and magnetically isolated from said emitter.

51. A method of determining the position and orientation of at least one three dimensional object in a three dimensional space, defined by a coordinate system, which comprises:

disposing a plurality of electromagnetic emitters, comprising a dispersing element so constructed as to radiate electromagnetic radiation over a solid angle that at least

approaches about a hemisphere in known spaced apart relationship to each other on a surface of said object;

providing at least one electromagnetic radiation generator spaced from said object;

providing at least one non-electric radiation guide means operatively associated with said emitter(s) and with said at least one generator(s);

generating electromagnetic radiation from generator(s);

transmitting said radiation, non-electrically through said radiation guide(s) to said emitter(s);

non-electrically radiating radiation from at least one of said dispersing elements;

receiving said emitted radiation by a plurality of electromagnetic radiation receivers;

determining the location of each emitter as a function of the angles between said received radiation and respective reference lines; and

converting said determined locations of said emitters to a position and orientation of said object in said three dimensional space.

52. An apparatus for determining the location of at least one point in three dimensional space relative to a three dimensional coordinate system defining said space comprising:

at least one emitter of electromagnetic radiation, comprising a radiation dispersing element that is adapted to emit said radiation in a substantially conical pattern that at least approaches a solid angle at least about equal to a hemisphere;

an electromagnetic radiation generator operatively associated with at least one of said emitters;

means for transmitting electromagnetic radiation generated by said generator to said associated emitter;

a plurality of electromagnetic radiation sensors, each of which is adapted to detect at least one electromagnetic ray emitted from at least one of said emitters;

where there are a plurality of emitters, means to differentiate electromagnetic radiation emitted by at least two of said emitters; and

means for determining the location of said emitter(s) relative to said three dimensional coordinate system as a function of a plurality of angles intercepted between rays of said radiation and at least one reference line;

wherein, as a consequence of said emitters emitting electromagnetic radiation at a solid angle at least approaching a hemisphere, determining the location of said emitters with greater accuracy that would have been the accuracy determined had the electromagnetic radiation been generated without said dispersing element.

53. The apparatus as claimed in claim 1, wherein at least one of said emitters comprises a light pipe image guide that is so shaped as to enable emitting electromagnetic radiation from an end thereof at a solid angle at least approaching a hemisphere.

54. The apparatus as claimed in claim 1, wherein at least one of said emitters comprises a concave lens with a negative focal length capable of emitting electromagnetic radiation at a solid angle at least approaching a hemisphere.

55. The apparatus as claimed in claim 1 wherein at least one of said emitters comprises a curved, convex mirror capable of emitting reflected electromagnetic radiation at a solid angle at least approaching a hemisphere.

56. An electrically neutral system for radiating electromagnetic radiation from an effective point source comprising:

an electromagnetic radiation generator;

an emitter of electromagnetic radiation comprising a radiation dispersing element that emits said electromagnetic radiation in a substantially conical pattern through a solid angle that at least approaches a hemisphere, and wherein said emitter is disposed a distance from said generator;

at least one optical fiber disposed in operative relationship to both said generator and said emitter such that it is adapted to transmit electromagnetic radiation from said generator to said emitter; and

an electric power source operatively associated with said electromagnetic radiation generator, wherein said generator is substantially electrically and magnetically isolated from said emitter.

57. The apparatus as claimed in claim 56 wherein at least one of said emitters comprises a light pipe image guide that is so shaped as to enable emitting electromagnetic radiation from an end thereof at a solid angle at least approaching a hemisphere.

58. The apparatus as claimed in claim 56 wherein at least one of said emitters comprises a concave lens with a negative focal length capable of emitting electromagnetic radiation at a solid angle at least approaching a hemisphere.

59. The apparatus as claimed in claim 56 wherein at least one of said emitters comprises a curved, convex mirror capable of emitting reflected electromagnetic radiation at a solid angle at least approaching a hemisphere.

60. A method of accurately determining the location of a point in three dimensional space which comprises:

electrically generating electromagnetic radiation;

non-electrically transmitting said electromagnetic radiation to at least one emitter comprising a radiation dispersing element adapted to emit electromagnetic radiation therefrom through a solid angle at least approaching a hemisphere; and

non-electrically emitting said electromagnetic radiation from said dispersing element in a pattern over a solid angle that at least approaches about a hemisphere;

61. A method of determining the position and orientation of at least one three dimensional object in a three dimensional space defined by a three dimensional coordinate system which comprises:

disposing a plurality of electromagnetic emitters, comprising a dispersing element adapted to radiate electromagnetic radiation in a substantially conical pattern over a solid angle that at least approaches about a hemisphere, in known spaced apart relationship to

each other on a surface of said object;

providing at least one electromagnetic radiation generator spaced from said emitter(s);

providing a non-electric radiation guide operatively associated at least one of said emitters and with said at least one generator;

generating electromagnetic radiation by said generator(s);

non-electrically transmitting electromagnetic radiation through said radiation guides to said emitter(s);

non-electrically radiating a pattern of radiation at least approaching a hemisphere from at least one of said dispersing elements;

receiving said emitted radiation by a plurality of electromagnetic radiation receivers;

determining the location of each emitter as a function of angles between said received radiation and respective reference lines; and

converting said determined locations of said emitters to a position and orientation of said object in said three dimensional space.

62. A method as claimed in claim 61 wherein said dispersing element comprises a light pipe image guide adapted to emit said electromagnetic radiation over a solid conical angle at least approaching a hemisphere.

63. An apparatus for determining the location of at least one point in three dimensional space relative to a three dimensional coordinate system defining said space comprising;

at least one emitter of electromagnetic radiation, comprising a radiation dispersing element that disperses electromagnetic rays emitted from said emitter in a pattern that at least approaches a solid angle at least about equal to a hemisphere and has a radiation pattern that at least closely approximates that of a point source of said radiation over said solid angle;

a plurality of electromagnetic radiation sensors, each of which is adapted to detect at least one electromagnetic ray emitted from at least one of said emitters, and to convert said detected ray into a signal;

where there are a plurality of emitters, means to differentiate at least two of said emitters; and

a signal processor adapted to calculate the location of said emitter(s) relative to the three dimensional coordinate system from said signal information;

wherein, as a consequence of said emitter(s) emitting electromagnetic radiation through said solid angle, determining the location of the centroid(s) of said emitter(s) with greater accuracy than would have been the accuracy determined had the electromagnetic radiation been generated without said dispersing element

64. The apparatus as claimed in claim 63 wherein at least two of said emitters radiate at different wavelengths.

65. The apparatus as claimed in claim 63 wherein said dispersing element is spaced from said radiation generator and further comprising transmission means adapted to transmit said generated radiation from said generator to said dispersing element.

66. The apparatus as claimed in claim 65 further comprising a plurality of dispersing elements.

67. A method of accurately determining the location of a point in three dimensional space comprising:

generating electromagnetic radiation;

non-electrically transmitting said electromagnetic radiation to at least one emitter, comprising at least one radiation dispersing element adapted to emit electromagnetic radiation therefrom through a solid angle at least approaching about a hemisphere;

non-electrically emitting said electromagnetic radiation from said dispersing element at a solid angle approaching about a hemisphere;

receiving a plurality of electromagnetic rays, emitted by said emitter, by an electromagnetic radiation detector;

determining angles intercepted between said rays and at least one reference line that has a known angular relationship with said radiation detector; and

from said angle, calculating a location of said emitter in said three dimensional space.

68. An electrically neutral system for radiating electromagnetic radiation from an effective point source and remotely receiving the same, comprising:

at least one source of electromagnetic radiation;

lens means adapted to couple said electromagnetic radiation to a plurality of non-electronic radiation transmission means;

at least one emitter, adapted to radiate electromagnetic radiation through a solid angle that at least approaches a hemisphere, electromagnetically coupled to at least one of said transmission means and spaced apart from said source; and

a plurality of means adapted to receive said radiated electromagnetic radiation spaced from said emitter(s) and not electrically connected to said emitters.

69. A system as claimed in claim 68 comprising a plurality of said transmission means and a plurality of emitters operatively associated with said plural transmission means.

70. A system as claimed in claim 69 comprising a single source of said electromagnetic radiation.

71. A system as claimed in claim 69 wherein said receivers are adapted to convert said received electromagnetic radiation to a signal, and further comprising a computer operatively associated with said receiver(s) adapted to receive said signals and to convert said signals into location(s) of said emitter(s) in a defined three dimensional volume.